Hyannis Water System

Maher Well 2 (4020004-02G)	**Emerging contaminants**			
raw water	Carbamazepine	9	ng/L	Pharms
air stripping !	Dilantin (phenytoin)	10	ng/L	H
	Meprobamate	3.8	ng/L	- HA
	Sulfamethoxazole	6.1	ng/L	
	Perfluorooctanoic acid (PFOA)	22	ng/L	400; 0.4 ug/l
	Perfluorooctanesulfonic acid (PFOS)	97	ng/L	200; 0.2 ug/l
	Triethyl phosphate (TEP)	10	ng/L	
	Tris(chloropropyl) phosphate (TCPP)	30	ng/L	
	Inorganic indicators of septic systems			
	Nitrate	0.9	mg/L	
	Boron	0.016	mg/L	
Hyannisport Well (4020004-03G)	**Emerging contaminants**			
	Antipyrine	1	ng/L	
	Carbamazepine	72	ng/L	Pharms
	DEET	6	ng/L	
	Dilantin (phenytoin)	4	ng/L	
	Gemfibrozil	1.2	ng/L	
	Meprobamate	5.4	ng/L	
	Sulfamethizole	1	ng/L	
	Sulfamethoxazole	41	ng/L	
	Perfluorooctanesulfonic acid (PFOS)	15	ng/L	200
	Triethyl phosphate (TEP)	10	ng/L	
	Tris(chloropropyl) phosphate (TCPP)	~13	ng/L	
	Tris(2-chloroethyl) phosphate (TCEP)	20	ng/L	
	Inorganic indicators of septic systems			
	Nitrate	5.3	mg/L	
	Boron	0.037	mg/L	
Airport Well 1 (4020004-10G)	**Emerging contaminants**			Pharms absent
	Perfluorooctanoic acid (PFOA)	14	ng/L	400
	Perfluorooctanesulfonic acid (PFOS)	16	ng/L	200
	Triethyl phosphate (TEP)	10	ng/L	
	Inorganic indicators of septic systems			
	Nitrate	0.3	mg/L	
	Boron	0.011	mg/L	

Raw water
10/2009

Hyannis Water System (continued)

Distribution System Sample

D S

Pharm

Finished Water

Emerging contaminants			
Carbamazepine		3	ng/L
Dilantin (phenytoin)		7	ng/L
Meprobamate		2.7	ng/L
Perfluorooctanoic acid (PFOA)	400	22	ng/L
Perfluorooctanesulfonic acid (PFOS)	200	110	ng/L ✓ Highest
Triethyl phosphate (TEP)	~~200~~	20	ng/L
Tris(chloropropyl) phosphate (TCPP)		40	ng/L
Inorganic indicators of septic systems			
Nitrate		0.9	mg/L
Boron		0.017	mg/L

Finished water

PFOA & PFOS Sources

Doug Heath to: Jane Downing, Karen Mcguire, Kevin Reilly, Davidj Gray, Julie Bliss — 06/16/2011 12:37 PM

Hi All,
PFOA and PFOS are prevalent and ubiquitous in the environment and in the blood of humans (with a half-life of 4 years). The compounds do not break down, and are used in many industrial and common household products. The only use in the aviation industry I could find was for PFOS as an ingredient in aviation hydraulic fluids. Fuels do not appear to be sources of PFOA or PFOS.
Please see the list below:

PFOA SOURCES HA 400ng/L

Product	Range (ppb)
Pre-treated carpeting	ND (<1.5) to 462
Carpet-care liquids	19 to 6750
Treated apparel	5.4 to 161
Treated upholstery	0.6 to 293
Treated home textiles	3.8 to 438
Treated non-woven medical garments	46 to 369
Industrial floor wax and wax removers	7.5 to 44.8
Stone, tile, and wood sealants	477 to 3720
Membranes for apparel	0.1 to 2.5 ng/cm
Food contact paper	ND (<1.5) to 4640
Dental floss/tape	ND (<1.5) to 96.7
Thread sealant tape	ND (<1.5) to 3490
PTFE cookware	ND (<1.5) to 4.3

PFOS SOURCES: HA 200 ng/L

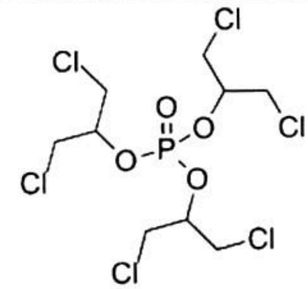
3M Scotchguard (phased out by 3M in 2000)

photolithography, mist suppressants for hard chromium plating, hydraulic fluids for aviation

Tris(1,3-dichloro-2-propyl)phosphate

From Wikipedia, the free encyclopedia

Tris(1,3-dichloro-2-propyl)phosphate is an organophosphate with the chemical formula $OP(OCH(CH_2Cl)_2)_3$. Also known as "Tris", this phosphate ester is used as a flame retardant.[1] The safety of this compound has been questioned.[2]

Tris(1,3-dichloro-2-propyl)phosphate	
	
IUPAC name	
Tris(1,3-dichloropropan-2-yl) phosphate	
Other names	
Tris, TDCP, TDCPP, Fyrol FR-2	
Identifiers	
CAS number	13674-87-8
Jmol-3D images	Image 1
SMILES	
Properties	
Molecular formula	$C_9H_{15}Cl_6O_4P$
Molar mass	430.9 g mol^{-1}
Appearance	Colorless liquid
✓(what is this?) (verify)	
Except where noted otherwise, data are given for materials in their standard state (at 25 °C, 100 kPa)	
Infobox references	

References

1. ^ Heather M. Stapleton, Susan Klosterhaus, Sarah Eagle, Jennifer Fuh, John D. Meeker, Arlene Blum, Thomas F. Webster (2009). "Detection of Organophosphate Flame Retardants in Furniture Foam and U.S. House Dust". *Environ. Sci. Technol.* **43** (19): 7490–7495. doi:10.1021/es9014019. PMC 2782704. PMID 19848166.
2. ^ Freudenthal RI, Henrich RT (2000). "Chronic toxicity and carcinogenic potential of tris-(1,3-dichloro-2-propyl) phosphate in Sprague-Dawley rat". *Inter J Toxicol* **19** (2): 119–125. doi:10.1080/109158100224926.

Retrieved from "http://en.wikipedia.org/wiki/Tris(1,3-dichloro-2-propyl)phosphate"

Categories: Organochlorides | Organophosphates

TEP

Triethyl phosphate

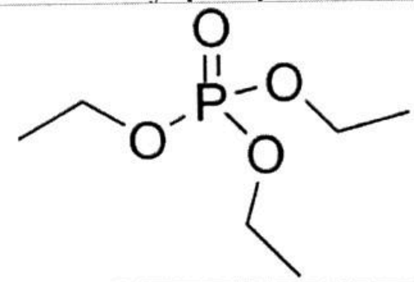
From Wikipedia, the free encyclopedia

Triethyl phosphate is a chemical compound with the formula $(C_2H_5)_3PO_4$. It is a colorless liquid. It is the triester of ethanol and phosphoric acid and can be called "phosphoric acid, triethyl ester".

Its primary uses are as an industrial catalyst, a polymer resin modifier, and a plasticizer (e.g. for unsaturated polyesters). In smaller scale it is used as a solvent for e.g. cellulose acetate, flame retardant, an intermediate for pesticides and other chemicals, stabilizer for peroxides, a strength agent for rubber and plastic including vinyl polymers and unsaturated polyesters, etc.[2]

Triethyl phosphate is also a common intermediate in the manufacture of pesticides.

Triethyl phosphate[1]



IUPAC name	Triethyl phosphate
Other names	Ethyl phosphate; Triethylphosphate; Tris(ethyl) phosphate; Triethoxyphosphine oxide
Identifiers	
CAS number	78-40-0 ✓
PubChem	6535
ChemSpider	6287 ✓
Jmol-3D images	Image 1
SMILES	
InChI	
Properties	
Molecular formula	$C_6H_{15}O_4P$
Molar mass	182.15 g/mol
Density	1.072 g/cm^3
Melting point	-56.5 °C, 217 K, -70 °F
Boiling point	215 °C, 488 K, 419 °F
Solubility in water	Miscible

✓(what is this?) (verify)

Except where noted otherwise, data are given for materials in their standard state (at 25 °C, 100 kPa)

Infobox references

History

It was studied for the first time by French chemist Jean Louis Lassaigne in the early 19th century.

See also

- Franz Anton Voegeli

References

1. ^ "Zhangjiagang Shunchang Chemical Co., Ltd". *Triethylphosphate*. http://www.shunchangchem.com/template/produe90.htm. Retrieved June 13, 2009.
2. ^ Triethylphosphate, International Programme on Chemical Safety

Retrieved from "http://en.wikipedia.org/wiki/Triethyl_phosphate"
Categories: Organophosphates | Plasticizers | Solvents | Ethyl esters

- This page was last modified on 22 April 2011 at 17:43.

CAPE COD COMMISSION

3225 MAIN STREET
P.O. Box 226
BARNSTABLE, MA 02630
508-362-3828
FAX: 508-362-3136

DATE:	April 27, 1995	#TR95006
TO:	Mr. Benjamin Jones Airport Manager Barnstable Municipal Airport 480 Barnstable Road Hyannis, MA 02601	
FROM:	Cape Cod Commission	
RE:	Development of Regional Impact Application Barnstable County Ordinance 94-10, Chapter A, Section 3G	
APPLICANT:	Mr. Benjamin Jones, Airport Manager	
PROJECT:	Rescue, Fire-fighting and maintenance facility Barnstable Municipal Airport Hyannis, MA 02601	
BOOK/PAGE:	Book 697, Page 294	

DECISION OF THE CAPE COD COMMISSION

SUMMARY

The Cape Cod Commission (the Commission) hereby approves with conditions the application of Mr. Benjamin Jones, Barnstable Airport Manager, for a Development of Regional Impact under Barnstable County Ordinance 94-10, Chapter A, Section 3G, for the construction of a 15,000 square foot two-story building to house all of the Airport's existing rescue, fire-fighting and snow removal equipment. The decision is rendered pursuant to the vote of the Commission on April 27, 1995.

PROJECT DESCRIPTION

The project consists of a proposed 15,000 square foot, two-story building to house all of the Airport's existing rescue, fire-fighting and snow removal equipment, which is currently stored and serviced at various sites within the Airport boundaries.

The Airport property is located within a Wellhead Protection Area for the Town of Barnstable. The facility will be located within the confines of the existing 448-acre Airport property, between Taxiway B and Airport Road on a parcel under two acres in size. The facility will include duty quarters for the emergency response crew, a small public lounge area, office, locker room, break room and toilet facilities. Storage will be provided for maintenance supplies and sand, but no salt. The project will incorporate a truck washing facility using a recycling water system. The facility is proposed to be sewered, and will provide a total of 15 additional parking spaces for employees.

Bldg sewered

PROCEDURAL HISTORY

The project was referred by Mr. Ralph Crossen, the Barnstable Building Commissioner, on February 2, 1995. The referral was received by the Cape Cod Commission on February 6, 1995. A site visit was conducted by the Subcommittee on February 21, 1995. Pursuant to Section 5 of the Act, a duly noticed public hearing was held on the project on April 4, 1995 and continued to April 27, 1995. Two public meetings were held on April 4, 1995 and April 10, 1995. On April 10, 1995, the Subcommittee voted to recommend to the full Commission that the proposed Airport Equipment Building be approved as a DRI, with conditions. A draft decision was presented to the full Commission on April 27, 1995. At this meeting the Commission voted unanimously to approve the project as a DRI subject to conditions. The public record was closed on April 27, 1995.

MATERIALS SUBMITTED FOR THE RECORD

A. Materials submitted by the Applicant:	
Letter from Mass. Historical Commission	2/10/95
DRI Application which includes a project plan, development plans, a letter from Mass. Natural Heritage, MEPA project change notice (9/8/94), a list of vehicles used in Airport maintenance and a list of hazardous materials	2/15/95
Letter modifying DRI Application concerning hazardous waste storage tank and replacement fuel tanks	2/27/95
Letter and attachments describing Deed Book and Page number, Abutters List, acknowledgement of DRI filing with Town agencies	3/10/95
Report of sewer line inspection	4/3/95
Letter and attachments: pages from FAA Advisory about safety restrictions on use of property	4/3/95

B. Materials submitted by the State:
Letters from Massachusetts Historical Commission and Natural Heritage Program were submitted by the Applicant. No other materials were submitted by the State.

C. Materials submitted by the Town:

DRI Referral Form and cover letter	2/6/95

D. Materials submitted by the public:
Oral testimony only at the public hearing. No written materials submitted.

E. Materials submitted by Cape Cod Commission:

Staff Project Referral Form and site map	2/13/95
Traffic comments on Staff Project Referral Form indicating no impacts	2/13/95
FAX-Letter to David Fisher about Hearing	2/16/95
Reminder to Subcommittee of Site Visit	2/17/95
Copy of Deed and Map showing Airport parcels	3/7/95
Staff Report	3/24/95
FAX-to David Fisher-Draft Findings and Conditions	4/7/95
FAX-to Ben Jones-Draft Findings and Conditions	4/7/95
FAX-to Ralph Crossen-Draft Findings and Conditions	4/7/95
Maps delineating area of critical habitat	No date

The Application and notice of the public hearing relative thereto, the Commission's staff reports, exhibits, minutes of all hearings and all submissions received in the course of the proceedings, including materials submitted on file #TR95006 are incorporated into the record by reference.

TESTIMONY

The Commission's Subcommittee received testimony at the April 4, 1995 public hearing on this project at the Selectmen's Conference Room at Barnstable Town Hall in Hyannis, MA.

Mr. David Fisher of Keyes Associates described the project and presented the site plan. He described the location of the proposed equipment building and surrounding land uses. He indicated the project was located in the watershed to Upper Gate Pond. The existing maintenance building located near the project site would be closed as a result of constructing the new facility. The proposed new facility would tie into the Barnstable wastewater treatment plant via an existing sewer line. UIC Storm water detention would be handled by an on-site infiltration basin. He described the exterior and proposed cladding of

to Sewage Plant

the building. He said that no additional vehicles or other maintenance facilities were being proposed other than this project. He also said that no additional usage of hazardous materials was proposed for the project. He said the project will also involve the removal of two existing underground fuel storage tanks and the installation of two new above-ground tanks of the same capacity as those being removed.

Andrea Adams, a planner with the Cape Cod Commission gave an overview of the Staff Report. She indicated that there were four issues of concern for the project's review: historic preservation and community character, water resources, hazardous materials/wastes and natural resources. She described the project as a consolidation of fire-rescue and vehicle maintenance activities currently taking place on the Airport property. Tom Cambareri of the Cape Cod Commission's water resources office provided an overview of the important regional water resources in the project area.

Ben Jones, the Airport manager, said the existing maintenance building was scheduled for closure and that the Airport would take all measures necessary to remediate any hazardous materials/waste releases. Greg Silverman, subcommittee chair, noted that a spill response plan should be developed to address emergencies.

Andrea Adams also noted that the Regional Policy Plan requires that commercial development provide 40% of the lot area, excluding wetlands, as permanent open space. The Staff Report had recommended a conservation restriction be provided for a portion of the Airport's open space to protect the Hyannis Ponds Complex, which contains globally significant rare species. Ms. Adams said that Commission's legal counsel had reviewed the project and determined that this standard would not apply to a municipal airport. Ms. Adams noted, however, that a 100-foot buffer to wetlands would be required to prevent adverse environmental impacts from the clearing of vegetation adjacent to runways proposed to maintain site distance to the maintenance building.

Mr. Jones said that initial surveys show there may need to be some limited clearing and topping of trees along the southwestern side of Upper Gate Pond to provide a sight line for the proposed project. He said the Airport does not have a problem with retaining a 100-foot buffer to Upper Gate Pond, Lewis Pond, Mary Dunn Pond and Lamson's Pond which are also all or partly on Airport property. He was also willing to limit clearing of a sight line for the proposed project along Upper Gate Pond to topping of trees rather than complete removal of vegetation.

Mr. Daniel Hanley of West Yarmouth was concerned that upgrading the Airport facilities would result in an increase in airplane traffic and noise levels. He also expressed concern about the wetlands and guarantees by the Airport that trees would be topped and/or left standing to protect the ponds. He felt the Commission should protect the ponds by establishing a set buffer area, restrictions on the topping of trees and how much vegetation could be removed.

Richard Andres of Barnstable questioned the usefulness of a buffer area to the ponds for habitat protection if the soil and understory vegetation could be disturbed. He felt it was important for buffer vegetation to be maintained in an undisturbed state.

The Public Hearing was continued to Thursday, April 27, 1995 at 3:00 p.m. at the Assembly of Delegates Chamber at the

Barnstable District Courthouse. At this hearing, Greg Silverman presented the draft Decision to the full Cape Cod Commission. He described the project as a reconfiguration and consolidation of existing services. He indicated the Airport was a relatively developed site already and that the project will provide a new facility to house the Airport's fire-fighting, rescue and maintenance equipment. He said the project had a number of benefits including better storage and management of hazardous materials and wastes, removal and replacement of underground fuel storage tanks, installation of a vehicle washing machine which will capture and process wastewater and provision of buffers around the coastal plain ponds which are areas of critical habitat located on the Airport property. He said the Subcommittee found that the project, with application of the conditions included in the draft Decision, is in conformance with the Minimum Performance Standards of the RPP. Sumner Kaufman asked if the Airport had considered methods to process waste de-icing fluid resulting from de-icing operations as part of the proposed facility. Mr. Ben Jones, Manager of Barnstable Municipal Airport, responded that the private airlines and not the Airport itself control the de-icing of planes. He added the Airport requires airlines use propylene glycol to de-ice planes, an additive found in many consumer products. He said the Airport has also done tests to analyze run-off from the taxiways and runways and found the only problem was one of high pH. Andrea Adams noted that Condition #8 had been slightly modified to reflect the Airport's desire that it be allowed to clean all vehicles under its control, and not just those connected to the fire-rescue and maintenance building, at the vehicle washing facility.

Sumner Kaufman moved to close the Public Hearing. Don LeBlanc seconded the motion. The Commission voted all in favor of the motion to close the Public Hearing.

Greg Silverman moved adoption of the draft Decision, approving the proposed fire-fighting, rescue and maintenance equipment facility with conditions, amended to reflect the testimony given at the Public Hearing. Herb Olsen seconded the motion. The Commission voted all in favor of adopting the draft Decision, approving the proposed project with conditions, as amended to reflect the testimony given at the Public Hearing.

JURISDICTION

The proposed project qualifies as a DRI under Chapter A, Section 3G, Barnstable County Ordinance 94-10 as a facility which is "any development providing facilities for transportation to or from Barnstable County, including but not limited to ferry ships, bus, rail, trucking terminals, transfer stations, air transportation and/or auxiliary uses and accessory parking or storage facilities so long as such auxiliary or accessory uses meet the criteria of Section 3(e)" of the Cape Cod Commission's Enabling Regulations. The proposal exceeds the Section 3(e) threshold for auxiliary uses greater than 10,000 square feet.

FINDINGS

The Commission has considered the application of Mr. Benjamin Jones for the proposed 15,000 square foot rescue, fire-fighting and snow removal equipment building to serve the municipal Airport in Barnstable, MA, and based on consideration of such application, the information presented at the public hearing and submitted for the record, the Commission makes the following findings:

1. The proposed development is located in a Wellhead Protection Area to the Barnstable Fire District and Barnstable Water Company public supply wells, and is in a Marine Recharge Area to Lewis Bay. It is also located 2,000 feet directly upgradient of the Mahar Wellfield which is the primary water source of drinking water for Hyannis.

2. Construction of the proposed project will replace an existing Airport rescue, fire-fighting and snow removal equipment building and will consolidate maintenance activities for this equipment which are already occurring on the Airport property.

3. The proposed project is intended to be serviced by the Hyannis municipal sewage treatment plant. This will result in the closure of an existing septic system and will satisfactorily address the 5 ppm standard in the RPP limiting non-point source nitrogen loading. A sewer connection permit will be required. The Applicant has submitted the results of an inspection of the existing line along old Mary Dunn Road which reveals it is intact and suitable for use.

4. The Applicant has submitted information indicating the amount of hazardous materials currently used and hazardous waste currently generated from rescue, fire-fighting and snow removal activities, which will not increase as a result of this project.

5. The DRI application indicates there will be two new bulk storage tanks for gasoline and diesel fuel. These new tanks will replace two existing fuel tanks located on the Airport fuel farm which can currently store 8,000 gallons. A letter submitted by the Applicant on February 27, 1995 to amend the DRI Application indicates the two new fuel tanks will have a combined maximum replacement capacity of 8,000 gallons.

6. Information submitted in the DRI Application indicates that there will be no major vehicle repairs undertaken at this facility. Vehicle maintenance will be limited to oil changes and tune-ups. The types of hazardous wastes generated by these activities will include oil and antifreeze, to be stored in an above-ground, double-walled two-chambered tank. Discussions with the Applicant indicate the Airport currently generates no more than 27 liquid gallons of hazardous waste a month.

7. The Applicant has stated that any buildings closed as a result of the development of the proposed Equipment Building will be subject to environmental investigations to determine the nature and extent of any existing contamination. The Applicant has also stated that any such contamination will be fully remediated according to applicable laws and regulations.

8. The Airport currently washes vehicles at various locations on the property without containment or other environmental safeguards. The proposed development will include a vehicle washing machine which has technologies designed to remove solids, oil, grease, fuels and heavy metals from wash water. The machine will generate approximately 93 gallons of oily waste at any one time.

9. The Applicant indicated that some of the private companies on the Airport property (Hertz, Budget Rent-A-Car) have their own specialized vehicle washing facilities. The Applicant agrees to restrict the use of the vehicle washing machine to only vehicles used by the Airport.

10. The proposed building will be a 15,000 square foot, two-story gray split face masonry structure with black smooth face masonry trim. Other buildings on and surrounding the Airport include brick, concrete masonry and metal structures of a similar size and scale.

11. The Massachusetts Historical Commission has determined the project is unlikely to affect significant historical or archeological resources.

12. The proposed facility will be located on an existing Airport runway apron in a previously developed portion of the site. A wildlife and plant habitat assessment under Section 2.4.1.1.B.1 of the RPP was not required for this project due to this location. In addition, the Massachusetts Division of Fisheries and Wildlife has indicated that rare and endangered species will not be adversely affected by the proposed project.

13. Section 6.1.4 of the RPP requires in part that commercial development which qualifies as a Development of Regional Impact provide 40% of the lot area excluding wetlands, as permanent open space. It has been determined that the Airport in question is a municipal use, the maintenance facility is in a pre-existing developed area, and construction on certain areas of the Airport property is restricted by the FAA for safety reasons. Therefore, Section 6.1.4 of the RPP is inapplicable to this project.

14. The Airport property is located adjacent to the Hyannis Ponds complex, an area of coastal plain ponds which supports an unusual concentration of globally significant rare species. The proposed project is likely to include limited clearing of vegetation adjacent to Upper Gate Pond, which is within this ponds complex. Section 2.3 of the RPP requires that a natural, undisturbed buffer of at least 100 feet width be maintained from the edge of coastal and inland wetlands including isolated wetlands to protect their natural functions.

CONCLUSION

Based on the above findings, the Cape Cod Commission hereby concludes:

1. The benefits of the project outweigh the detriments. This conclusion is supported by the findings that the project will allow for the consolidation of the management of hazardous materials and wastes currently used on the Airport property, the installation of improved containment systems for these materials and wastes, improved employee training programs in emergency response, the remediation of existing old equipment buildings on the Airport property, replacement of underground fuel tanks with modern, above-ground tanks, the use of sewer as opposed to a septic system, use of a vehicle washing machine which provides processing and containment of wash waters and provision of an undisturbed buffer around coastal plain ponds located on the Airport property.

2. The proposed project is consistent with the relevant Minimum Performance Standards of the Regional Policy Plan, subject to the attached conditions.

3. The proposed project is consistent with the Town of Barnstable development bylaws.

The Cape Cod Commission hereby approves with conditions the proposed rescue, fire-fighting and maintenance facility for the Barnstable Municipal Airport in Hyannis, MA as a Development of Regional Impact, pursuant to Section 12 and 13 of the Act, provided the following conditions are met:

CONDITIONS

1. The plans as submitted and listed in this decision, as modified by the following conditions, shall become part of the written decision and any changes shall be approved by the Cape Cod Commission or its designee.

2. The Applicant shall obtain a Certificate of Compliance from the Cape Cod Commission or its designee before the local official responsible for issuing Certificates of Occupancy may issue a permanent or temporary Certificate of Occupancy for any portion of the proposed project. All conditions attached to this decision must be met prior to the issuance of a Certificate of Compliance from the Cape Cod Commission.

3. The Applicant shall obtain all necessary State and local permits for the project.

4. The amount of new hazardous materials used, generated, treated or stored on the Airport property in connection with this project shall be no more than 275 liquid gallons, or its equivalent, at any one time.

5. The Airport shall remain at Very Small Quantity Generator (VSQG) status for the purposes of any hazardous waste generated from this project. A VSQG may generate no more than 27 liquid gallons of hazardous waste per month.

6. Prior to receipt of a Certificate of Compliance from the Cape Cod Commission, the Airport shall develop and implement a plan designed to train employees about workplace safety and how to prevent releases of hazardous materials or wastes. A copy of the final plan shall be submitted to the Cape Cod Commission and the Hyannis Fire Department.

7. The Airport shall provide to the Cape Cod Commission copies of all test results and surface or subsurface investigations conducted to evaluate possible contamination at the site of any maintenance facility which is closed or the functions of which are transferred to the proposed new building as part of this project. This information shall also include the results of any similar investigations conducted during removal of the two existing underground fuel storage tanks. The Applicant shall provide written notice of the underground tank removal to the Commission upon completion.

8. Use of the vehicle washing machine shall be restricted to only those vehicles owned and operated by the Airport facility.

9. The Airport shall provide documentation of the results of bi-annual (every six months) inspections of the facility for proper storage and handling of hazardous materials and wastes to the Barnstable Board of Health, Hyannis Fire Department and Cape Cod Commission.

10. Prior to receipt of a Certificate of Compliance from the Cape Cod Commission, The Applicant shall submit to the Commission documentation of a Barnstable Department of Public Works sewer connection permit.

11. The Applicant shall maintain a natural, undisturbed buffer of at least 100 feet in width from the high water mark of the following ponds: Upper Gate Pond, Lewis Pond, Mary Dunn Pond, Lamson's Pond and the two unnamed small ponds near Lamson's and Mary Dunn Ponds shown on Sheet 1 of the abutting parcels (July 23, 1976/Folder 12-38/Book 308, pg. 76). No disturbance of the buffer area may occur, including but not limited to, tree and vegetative pruning, tree topping and any interference with the soil or subsurface layer. The Applicant shall maintain a natural buffer of at least 200 feet in width from the high water mark of these ponds, where the Applicant shall be restricted to topping of trees sufficient to provide a line of sight required for safety reasons connected to the Barnstable Airport equipment building. The 100 and 200-foot buffer areas shall be delineated on the final recorded site plan and attached to this decision.

Kenneth Brock, Chairman

5/2/95
Date

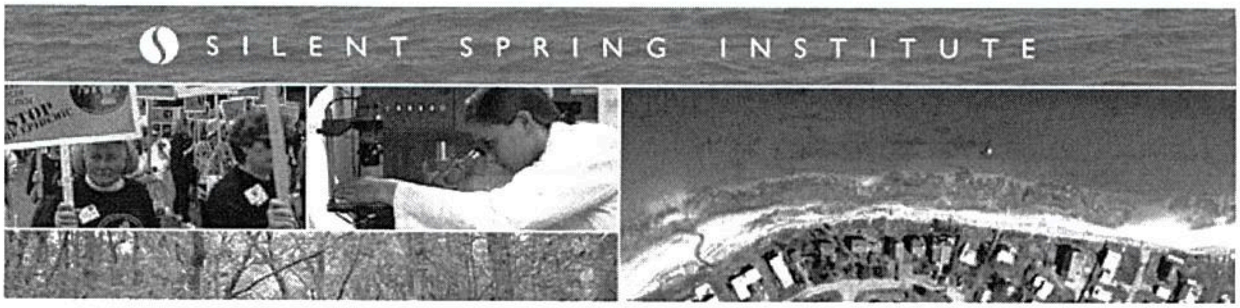
COMMONWEALTH OF MASSACHUSETTS

Barnstable, ss.

Subscribed and sworn to before me this 2nd day of May 1995

Katharine L Peters
NAME, Notary

My Commission expires:



RESEARCHING THE ENVIRONMENT AND WOMEN'S HEALTH

Emerging Contaminants in Cape Cod Drinking Water

Laurel Schaider, Ph.D.
Ruthann Rudel, M.S.
Sarah Dunagan, M.A.
Janet Ackerman
Laura Perovich
Julia Brody, Ph.D.

May 2010

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Executive Summary

Overview

In October 2009, Silent Spring Institute, in collaboration with nine Cape Cod public water suppliers, tested for emerging contaminants in public drinking water supplies to learn more about how septic systems and other sources of groundwater contamination are affecting water quality on the Cape. The emerging contaminants we tested for were pharmaceuticals, hormones, personal care products, herbicides, alkylphenols, flame retardants and perfluorinated chemicals. Samples of untreated water from 20 wells and treated water from 2 distribution systems were tested for over 90 emerging contaminants altogether. Many of the target compounds, including pharmaceuticals, hormones, personal care products, herbicides, flame retardants and perfluorinated chemicals, have been found in other U.S. drinking water supplies.

Overall, a majority of samples tested contained emerging contaminants at parts per trillion levels, indicating that chemicals in household and commercial wastewater can seep from septic systems into groundwater and make their way into drinking water. Several chemicals were detected at levels that approached or exceeded the highest levels found in other studies of U.S. drinking water supplies. While there are no enforceable drinking water standards for these chemicals, health-based guideline values have been developed for three of the detected chemicals, and the levels in all samples fell below these guideline values. However, health-based guidelines are not available for most of the chemicals we detected, and the health effects of exposure to low levels of these types of compounds, especially in complex mixtures, are not yet known. Our results demonstrate widespread impact of wastewater, primarily from septic systems, on Cape drinking water supplies and highlight the need for a comprehensive strategy for protecting Cape Cod drinking water supplies.

Findings

- Three quarters of tested wells, as well as the two distribution systems, contained at least one emerging contaminant. Five wells did not contain detectable levels of any of the emerging contaminants tested.
- Of 92 emerging contaminants, 18 were detected at least once, including pharmaceuticals, an insect repellent, flame retardants and perfluorinated chemicals.
- The two most frequently detected chemicals were an antibiotic, sulfamethoxazole, and a perfluorinated chemical, PFOS, a consumer product additive used in used in stain-resistant and nonstick coatings, as well as in fire-fighting foams.
- In general, samples containing higher levels of nitrate and boron (established indicators of septic system contamination on Cape Cod) and wells located in more highly populated areas tended to have more frequent detections and higher levels of the emerging contaminants.
- While septic systems are likely the primary source of these chemicals, commercial sources also may be important. Two perfluorinated chemicals used in fire-fighting foams and aviation hydraulic fluids were found at relatively high levels in Hyannis wells downgradient of the airport. Additional testing is required to pinpoint the sources of these chemicals. Airport
- In many cases, levels of emerging contaminants in Cape Cod wells were relatively low to moderate compared to the results of previous studies of emerging contaminants in other U.S. drinking water supplies. However, in some instances, the levels we measured were among the highest. In particular, the levels of two pharmaceuticals, sulfamethoxazole and

dilantin, as well as PFOS, were found to equal or exceed the highest levels measured in other studies, except for a few cases of industrial contamination.

The health effects of exposure to low levels of these types of compounds, especially when they occur together in complex mixtures, are not known.

- Enforceable drinking water standards have not been developed for any of the detected chemicals.
- Health based guideline values are available for three of the emerging contaminants that were detected. No samples exceeded the health-based guidelines for these chemicals, although perfluorinated chemicals were detected at levels one-half the lowest guideline value in two samples. Guideline values have not been established for many emerging contaminants.
- Detected levels of emerging contaminants ranged from 0.1 to 100 nanograms per liter (parts per trillion). By comparison, other organic chemicals, such as volatile organic compounds, are typically regulated in drinking water at the parts per billion range (1000 nanograms per liter or higher). For pharmaceuticals, even the highest levels detected in drinking water samples were many orders of magnitude lower than the amount found in a typical dose of a medicine, which is usually higher than 100,000,000 nanograms per day (a typical individual drinks about 1-2 liters water/day). For chemicals associated with household products such as perfluorinated chemicals and flame retardants, direct contact with these products would likely lead to higher levels of exposure.
- However, there are reasons to limit exposures to these chemicals through drinking water. Pharmaceuticals are biologically active in small quantities and are not intended for the general population. Exposures that occur at sensitive developmental stages (for instance, in fetuses and infants) may have effects at lower doses than exposures during other life stages. Furthermore, we have limited understanding of potential health effects of mixtures of pharmaceuticals and other chemicals at low levels.

Conclusions

While the levels of pharmaceuticals, flame retardants, and other emerging contaminants in drinking water are not currently regulated, it is prudent to find ways to prevent discharges from septic systems and treatment plants from impacting drinking water supplies. In order to build on the efforts of many Cape communities to protect drinking water quality, additional measures are needed to reduce the impacts of wastewater on Cape drinking water supplies.

- Better protection of supply wells will require additional measures to prevent contamination in Zone I and Zone II wellhead protection areas, including sewering to eliminate septic system discharges, enforcement of zoning regulations, and land acquisitions to protect open space.
- In order to reduce chemical inputs into water, Cape residents should properly dispose of unused medications and hazardous products, reduce their reliance on household products containing harmful chemicals, maintain septic systems and support local efforts to prevent contamination in wellhead protection areas.

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Introduction

Why did we do this study?

In recent years, traces of pharmaceuticals and other chemicals have been found in drinking water supplies throughout the United States. For example, in 2008 the Associated Press reported that the drinking water of 41 million Americans in 24 major metropolitan areas contained trace levels of pharmaceuticals.[1] In Philadelphia alone, the water contained 17 pharmaceuticals, including pain relievers, anticonvulsants and medications for heart conditions. Contaminants present in wastewater can make their way into drinking water after discharges from septic systems and wastewater treatment plants are released into groundwater, rivers and lakes. Some of the chemicals found in drinking water have been shown to act as endocrine disrupting compounds (EDCs), chemicals that can mimic the behavior of estrogens and other hormones in the body.

Drinking water supplies on Cape Cod are vulnerable to contamination by household wastewater. Chemicals that are not broken down in septic systems can leach into the Cape's shallow unconfined aquifer. The aquifer contains porous sandy soils with low levels of organic matter that lead to relatively fast movement of groundwater and limited breakdown of organic contaminants.[2] A 1994 U.S. Geological Survey (USGS) study estimated that up to 26% of the water pumped from public supply wells originated as discharge from septic systems.[3] In recent decades, the Cape's growing population has put increasing stress on drinking water resources.[4] Previous studies by Silent Spring Institute have found pharmaceuticals, hormones, and other chemicals in groundwater downgradient of septic systems,[5, 6] and a 2005 USGS study found pharmaceuticals and organophosphate flame retardants in several Cape Cod drinking water wells (public, semi-public and private).[7] Silent Spring Institute detected pharmaceuticals and hormones in several Cape Cod ponds, especially those downstream of more densely populated residential areas, suggesting septic systems are a source of these contaminants into groundwater.[8]

Silent Spring Institute has been studying water quality on Cape Cod for over 10 years. Our goal is to understand whether there are environmental factors linked to the Cape's elevated incidence of breast cancer. One of our questions is whether EDCs and other contaminants in drinking water play a role. Previous research has suggested that there may be a link between exposure to certain EDCs and hormonally-active diseases such as breast cancer.[9, 10] As part of Silent Spring Institute's Cape Cod Breast Cancer and Environment Study, an initial analysis used historical nitrate levels in drinking water as a tracer of contaminants from septic system or wastewater treatment plant discharge. This analysis did not show a link between more-impacted drinking water and breast cancer risk.[4] However, nitrate data were not available far into the past and we could not estimate exposure for participants who lived off Cape or used private wells. There have been few direct measurements of EDCs and other contaminants in Cape Cod drinking water supplies. A recent article by scientists at Boston University reported elevated breast cancer risk for women in the 1980s and early 1990s in Hyannis compared with other Upper Cape areas and associated this increase with contaminants in the Hyannis Water System supply.[11] These contaminants could include wastewater-related chemicals from the wastewater treatment plant in Barnstable, septic system discharges upgradient of the wells, and/or groundwater contaminants from the airport that are known to affect the Maher wells.

The goal of this new study was to measure the levels of pharmaceuticals and personal care products (PPCPs), EDCs and other emerging contaminants in Cape Cod public drinking water supplies. We wanted to know whether chemical levels are higher in wells located in more heavily populated areas and in wells that contain typical markers of wastewater contamination, such as elevated levels of nitrate and boron. The concentrations of emerging contaminants in Cape Cod water supplies were compared to studies of other U.S. drinking water supplies. Our results illustrate the importance of continued efforts to protect the Cape's drinking water supplies, and have implications for decisions about upgrading the Cape's wastewater infrastructure.

Which wells did we test?

We tested untreated (raw) water samples from 20 public drinking water supply wells located throughout Cape Cod. All water suppliers in Barnstable County were provided the opportunity to participate in this study. Of these, the nine participating water districts were: Barnstable Fire District, Brewster Water Department, Buzzards Bay Water District, Centerville/Osterville/Marstons Mills Water Department, Chatham Water Department, Cotuit Water Department, Dennis Water District, Falmouth Water Department and Hyannis Water System. In addition, samples were collected from the distribution systems of two of these water districts. All water samples were collected in late October 2009 by members of Silent Spring Institute's research staff. We also collected quality assurance/quality control (QA/QC) samples, including blanks and duplicates (see Appendix 3).

In selecting which wells to test, we used nitrate concentrations over the past 5 years and the level of residential development in well recharge areas as indications of wastewater impact. A well's recharge area is the area of land that potentially contributes water to that well. We prioritized wells that were most likely to be affected by wastewater; however, to get a sense of the range of impacts, we also included some wells with low to moderate levels of nitrate and some wells located in less populated areas.

We are grateful to the participating water districts for their voluntary collaboration in this project. Public water suppliers are not required to test for any of the emerging contaminants that we studied, and their participation demonstrates their commitment to learning about the condition of their water supply and their leadership in protecting water quality in the future.

What did we test for?

Based on previous studies of surface water, groundwater and drinking water on Cape Cod and throughout the U.S., we developed an initial list of chemicals that had been most frequently detected. We were particularly interested in chemicals thought to be endocrine disruptors. We used this initial list to evaluate the capabilities of several commercial laboratories and subsequently to select our final list of chemicals.

Overall, we tested for 92 emerging contaminants, including:

- 53 pharmaceutically-active compounds (over-the-counter and prescription drugs, caffeine, nicotine, and others)
- 8 hormones (naturally-occurring and synthetic)
- 4 personal care product ingredients (DEET, triclosan, 2 musk fragrances)
- 2 perfluorinated chemicals (surfactants used in non-stick and stain resistant consumer products and in industrial products)
- 5 herbicides (lawn care)
- 4 alkylphenols (breakdown products of some detergent compounds)

- 16 organophosphate flame retardants (used in many household products)

Appendix 2 provides a complete list of chemicals.

Water samples were also tested for nitrate and boron. These two chemicals occur naturally in Cape Cod groundwater at low levels, but high levels of nitrate and boron are indicative of contamination from septic systems or wastewater treatment plants. We analyzed these two chemicals primarily to investigate whether they could be useful indicators for predicting the presence of emerging contaminants. No samples exceeded the drinking water standard for nitrate (10 mg/L), and all samples were at least 100 times lower than the U.S. Environmental Protection Agency's lifetime health advisory level for boron (5 mg/L).

Chemical analyses were performed at two commercial laboratories that have the analytical capabilities to measure these types of chemicals at the parts per trillion levels typically found in drinking water. One part per trillion (ppt) is equivalent to one nanogram per liter (ng/L), or 0.0000001 milligrams per liter (mg/L). Laboratory reporting limits (the lowest concentration that we could measure) ranged from 0.1 ng/L to 1500 ng/L (0.0000001 to 0.0015 mg/L).

Results and interpretation

What did we find?

Many Cape Cod public water supplies are impacted by emerging contaminants. In most cases, the likely source of these contaminants is septic systems. Of the 20 wells and 2 distribution systems that we tested, 15 wells and both distribution systems had detectable levels of at least one of the emerging contaminants that we measured (Figure 1). Our results show a wide range in the number of emerging contaminants detected in each sample and in the measured levels of these chemicals. Table 1 provides a summary of the chemicals that were detected in at least one sample, and Appendix 1 provides the results for each individual sample.

- Of the 92 emerging contaminants that we tested for, 18 were detected in at least one water sample. These included 9 pharmaceuticals, 1 insect repellent, 2 perfluorinated chemicals, 1 alkylphenol and 5 organophosphate flame retardants. The majority (84%) of the 92 chemicals were not detected in any samples. See Appendix 2 for a complete list of chemicals included in this study.

- The number of emerging contaminants that were detected in a single sample varied from zero to 12 (Figure 2).
  - 5 samples had no detectable emerging contaminants
  - 7 samples had detectable levels of one emerging contaminant
  - 6 samples had detectable levels of 2 to 5 emerging contaminants
  - 4 samples had detectable levels of 7 to 12 emerging contaminants

In general, samples containing higher levels of nitrate and boron and wells located in more highly populated areas tended to have more frequent detections and higher levels of emerging contaminants. Tables 2, 3 and 4 and Figure 3 show the average number of chemicals detected according to nitrate and boron levels and residential density in well recharge areas.

- The average number of chemicals increased with the level of nitrate. On average, low nitrate wells contained 0.6 chemicals, moderate nitrate wells contained 3.1 chemicals, and high nitrate wells contained 6.5 chemicals.

- The average number of chemicals detected in samples containing higher levels of boron (4.4 chemicals) was around 11 times higher than in samples containing lower levels of boron (0.4 chemicals).

- In wells located in more heavily populated areas (around 20% of recharge area or more occupied by residential development), the average number of chemicals detected in each sample was 1.8 times higher (3.4 versus 1.9) than in wells located in less heavily populated areas (around 10% of recharge area or less occupied by residential development). Overall, nitrate and boron appeared to be better markers of impact than the extent of residential development alone.

- The two most frequently detected chemicals were sulfamethoxazole, an antibiotic, and the perfluorinated chemical PFOS. Sulfamethoxazole was detected in 1 of 7 (14%) low nitrate samples and in 12 of 15 (80%) moderate and high nitrate samples. PFOS was detected in 1 of 7 (14%) low nitrate samples and in 8 of 15 (53%) moderate and high nitrate samples. *

- Nine pharmaceuticals were detected in at least one sample. On average, the sum of the detected concentrations for these 9 pharmaceuticals was <0.1 ng/L in low nitrate wells, 13 ng/L in moderate nitrate samples, and 87 ng/L in high nitrate samples (Figure 4).

In general, Cape Cod drinking water supplies did not contain detectable levels of hormones and alkylphenols, two classes of endocrine disrupting compounds that Silent Spring Institute previously found in Cape Cod ponds and in groundwater impacted by septic system discharge. Because of our interest in factors that might affect breast cancer on Cape Cod, Silent Spring Institute has focused our research on identifying exposure to hormones and endocrine disruptors. We did not find detectable levels of any of the 8 hormones that we tested for, and we detected trace levels of one weakly estrogenic alkylphenol, nonylphenol, in just one sample. These findings are in contrast to previous work by Silent Spring Institute and others on Cape Cod[2, 5, 6, 8] showing the persistence of these types of chemicals in Cape groundwater, although some studies on the Cape have suggested bacterial breakdown of hormones and nonylphenol can occur as they move through groundwater.[12] We will continue to look for these chemicals in private well testing on Cape Cod, beginning in the fall of 2010, to gain a better understanding of their fate in Cape Cod groundwater.

Among the chemicals that we did detect, the perfluorinated chemical PFOA and several of the organophosphate flame retardants are suspected carcinogens and the perfluorinated chemicals are endocrine disruptors that affect thyroid hormones and cholesterol metabolism. Laboratory studies show that PFOA, a perfluorinated chemical, alters mammary gland development and causes tumors in the mammary gland and other organs. Other health effects, such as neurotoxicity, have been observed from some of the organophosphate flame retardants we detected (see Table 5b). These effects have been seen in animal studies at much higher levels of exposure than are likely from drinking tap water, and the levels we detected are below available health-based guidelines.

For many chemicals, including most of the chemicals we detected, there is limited information on their ability to act as endocrine disruptors. In the past, chemicals have not routinely been screened for their ability to act as endocrine disruptors. As the importance of endocrine disruption is becoming more widely recognized, better screening tools are needed to identify which chemicals have the potential to act as EDCs.

AIRPORT

While septic systems are likely the primary source of these chemicals, some other types of sources also may be important. In particular, the Barnstable Municipal Airport may be a source of two perfluorinated chemicals. The highest concentrations of two perfluorinated chemicals, PFOS and PFOA, were found in samples collected from two wells and a distribution system known to be contaminated by a plume of petroleum hydrocarbons and volatile organic compounds from the Barnstable Municipal Airport. Treatment of water from these two wells effectively reduces the levels of regulated contaminants, but is not effective for chemicals with low volatility, such as PFOS and PFOA. Studies in other locations have shown that groundwater downgradient of airports can be contaminated by PFOS and PFOA, which are

DS too

Other airports

found in some fire-fighting foams.[13] Discharges from the wastewater treatment plant in Barnstable contribute water to the Hyannisport well, as do a large number of septic systems.[3] Construction activities may also be a source of certain organophosphate flame retardants.[14]

How do Cape Cod results compare with health guidelines and other studies?

We evaluated potential health effects by comparing levels of emerging contaminants detected on Cape Cod with health-based guidelines and with the results of other U.S. drinking water studies. There are currently no federal or Massachusetts drinking water regulations for any of the emerging contaminants that we detected. Water suppliers are not required to test for any of the organic compounds in our study.

In several cases, state and federal agencies have developed health-based guidelines, which incorporate information about health effects from animal and human studies. These guideline values are designed to indicate levels in drinking water that pose little to no health risk, although it is possible that there can be health effects below these guideline values because they may not adequately protect sensitive populations or account for exposures to many chemicals together. For most of the chemicals we detected, there are no health-based guidelines, so we also compared Cape Cod results with the results of previous measurements of emerging contaminants in untreated and treated drinking water throughout the U.S.

PFOS
PFOAs
*

Health-based drinking water guidelines are available for several of the organic chemicals detected in Cape public drinking water. No samples exceeded the health-based guidelines for these chemicals. For the two perfluorinated compounds and one of the organophosphate flame retardants we detected, federal and regional U.S. Environmental Protection Agency (EPA) offices[15, 16] and several states[17, 18] have developed health-based guidelines, which are not enforced but provide a recommended level designed to protect human health.

- For PFOA, the highest level we detected (22 ng/L) was about one-half of the New Jersey Department of Environmental Protection's health-based guideline of 40 ng/L for PFOA, and was around 15 times lower than the Minnesota Department of Health's health-based value of 300 ng/L and EPA's short-term provisional health advisory value of 400 ng/L.
- For PFOS, the highest level we detected (110 ng/L) was about one-half of the EPA's short-term provisional health advisory value of 200 ng/L, and was about one-third of the Minnesota Department of Health's health-based value of 300 ng/L for PFOS.
- For TCEP, the highest level we detected (20 ng/L) was more than 100 times lower than EPA Region 9's drinking water screening level of 3,400 ng/L.

Compared to previous studies of emerging contaminants in drinking water supplies, in many cases the levels measured in Cape Cod wells were in the low to middle part of the range in levels measured in previous studies. However, in some instances, the levels we measured were among the highest. In particular, the levels of two pharmaceuticals and one perfluorinated chemical were found to equal or exceed the highest levels measured in other studies (see Table 1). In particular, the level of sulfamethoxazole, an antibiotic, in one sample was higher than the maximum in two other U.S. studies and the same as the maximum level in a third. In addition, two samples contained levels of dilantin, an epilepsy medication, Hyannis Dist Sys

that were higher than the maximum concentration found in a survey of 19 U.S. water supplies, many of which were thought to be impacted by wastewater. The levels of PFOS in one well and one distribution system exceeded the highest levels found in two other drinking water studies, including one that sampled wells thought to be impacted by a facilities that produced or handled perfluorinated chemicals, although they were lower than the levels found in areas known to be highly impacted by PFOS production.

The health effects of exposure to low levels of organic wastewater compounds, especially in complex mixtures, are not known. While the presence of a chemical alone does not necessarily mean that it is harmful, anticipating the effects of low level exposures to chemicals such as pharmaceuticals and EDCs in humans is difficult.

- Chemical levels that we detected were well below 1000 ng/L (1 part per billion, or ppb). Other organic chemicals, such as volatile organic compounds, are typically regulated in drinking water above 1000 ng/L. For pharmaceuticals, even the highest levels detected in well water samples were many orders of magnitude lower than the amounts found in a typical dose of a medicine. For instance, for sulfamethoxazole, a person would need to drink 80 million 8-oz cups of water from the well with our highest detected level in order to ingest the amount in a single daily dose. For chemicals associated with household products such as perfluorinated chemicals and organophosphate flame retardants, direct contact with products containing these chemicals would likely lead to much higher levels of exposure.

- However, there are reasons to limit exposures to these chemicals through drinking water. In particular, exposures that occur at sensitive developmental stages (for instance, in fetuses and infants) may have effects at lower doses than during other life stages. Furthermore, while people are exposed to complex mixtures of chemicals, most studies focus on one chemical at a time, so we have limited understanding of the potential health effects of mixtures of pharmaceuticals and other chemicals at low levels. Some preliminary studies using human cell lines have shown that mixtures of low levels of pharmaceuticals can cause effects that were not observed for these chemicals individually.[19] In addition, some pharmaceuticals can be biologically active (for instance, in fish) at very low levels -- even well below 1 ppb -- and often have side effects that are not taken into account when considering only intended doses. More information about the effects of some of these chemicals in laboratory animal studies can be found in Table 4.

Future drinking water regulations may include some of the chemicals detected in Cape drinking water supplies. The EPA currently regulates around 90 contaminants in drinking water. In the future, the EPA may include more emerging contaminants in their list of regulated chemicals in drinking water. The EPA's most recent Candidate Contaminant List (the list of chemicals being considered for future regulations) included 2 chemicals that we detected, PFOA and PFOS, as well as several hormones and an antibiotic. Drinking water regulations are established after extensive scientific studies to understand the health effects of chemicals and the levels that may be harmful. Much of this information is lacking for many emerging contaminants. ✓ 90

Keep in mind

PFOS
PFOA

Drinking water is just one pathway by which people are exposed to chemicals. Perfluorinated chemicals and organophosphate flame retardants are often found in clothing, furniture and other household products, so touching these products directly or inhaling household dust and air may potentially be much larger routes of exposure. In addition, exposure to perfluorinated compounds can occur through eating food that has come into contact with cookware and packaging containing PFOA. Based on studies in other communities, drinking water from the well with the highest PFOA concentration would be expected to increase one's total PFOA exposure by about 50%.[17] In general, household exposures to these types of chemicals are not well understood; in fact, one of Silent Spring Institute's research aims is to measure exposures to these types of chemicals and others within people's homes.

The levels of emerging contaminants in untreated well water samples may not represent the levels in tap water. Tap water in Cape Cod water distribution systems is a mixture of water from all the wells that provide water for that district. Because we chose to test mostly wells that were likely to be impacted by wastewater, the chemical levels in the wells we tested may be higher than the average levels in the distribution systems. All water districts adjust the pH of their water to prevent corrosion, and some water districts add chlorine as a disinfectant before water enters the distribution system. Previous studies have shown that chlorine can react with some of these chemicals,[20] reducing their levels but potentially leading to the formation of new, secondary chemicals, some of which are known to be harmful.

What you can do

If you are concerned about organic contaminants in your drinking water, you may wish to install a home water filtration system. In general, filtration products that contain a solid carbon block filter have been shown to effectively reduce levels of many types of organic contaminants, although results will be different for each individual chemical. Filter pitchers that contain granular activated carbon will also remove organic contaminants. Some water filters are independently tested for dozens of organic contaminants to demonstrate their effectiveness, although the specific emerging contaminants that we measured are not routinely tested. However, many water suppliers do not recommend home filtration systems. Improper use, for example not changing filters frequently enough, can lead to pathogens and other contaminants being released into the filtered water.

While some people drink bottled water as an alternative to tap water, the levels of emerging contaminants in bottled drinking water are not known, and regulatory monitoring of bottled water is less extensive than for public water supplies. There is no routine testing for emerging contaminants in bottled water and there are no published reports of measurements of PPCPs, EDCs and other chemicals in bottled water. While some bottled water comes from pristine water sources, some is simply tap water that may or may not be treated to remove chemicals. Furthermore, bottled water sits for extended periods of time in plastic containers, which may release chemicals into the water. Finally, the production of bottled water is far more resource-intensive than the sustainable use of local groundwater.

Ultimately, reducing the levels of pollutants in drinking water will require a concerted effort to reduce the amount of chemicals released into the Cape's groundwater aquifer and increased measures to protect drinking water supplies. Here are some steps you can take:

- Properly dispose of unused and expired medications. With the exception of a small number of controlled substances, most medications should not be flushed. The U.S. FDA provides guidelines (see "Additional Information" section) for consumers on proper disposal of medicines. Ask your pharmacy or town Board of Health about local programs for unwanted medications, and encourage local officials to create and publicize such programs. To reduce the potential for unwanted medications in your home, buy only what you will use and ask your doctor for trial sizes of new medications.

- Consider purchasing household products, clothing and furnishings made from natural fibers and without chemical additives such as dyes, stain-resistant coatings, antimicrobials, flame retardants, and fragrances. Avoid using harmful chemicals in your garden and lawn.

- Avoid dumping hazardous chemicals in your sink, on the ground or into storm sewers. Ask your town for information about hazardous waste collection days.

- Have your septic system regularly inspected and pumped. The Massachusetts Department of Environmental Protection (MassDEP) recommends pumping septic systems every 1-3 years.

- Support efforts to protect the Cape's shallow sole source aquifer from wastewater contamination, especially from septic systems. Installing sewers in public well recharge zones (also known as Wellhead Protection Areas or MassDEP Zone IIs) will prevent contaminants in septic system discharges from getting into drinking water. Wells with greater evidence of impacts could be considered priorities for Zone II protection efforts or reduced use.

- Support land conservation and efforts to limit development near public supply wells, for example through land trusts and programs like the Cape Cod Land Bank. Support enforcement of state and local laws that prohibit or limit potentially detrimental land uses within public well recharge zones.

- Support efforts to promote more thorough testing of chemicals before they go into production. Chemicals are present in wastewater because they are present in consumer products. However, many of these chemicals have not been thoroughly tested to understand their health effects.

If you want more information, contact your local water district or Silent Spring Institute at info@silentspring.org or call 617-332-4288.

Next steps

Compared to public wells, private wells may be even more vulnerable to septic system impacts. Past work has shown higher nitrate levels in private wells than in public wells. Silent Spring Institute plans to test for a similar list of emerging contaminants in 20 Cape Cod private wells in fall 2010.

Report yet?

While septic systems are likely the primary source of emerging contaminants in Cape drinking water supplies, our results showed that there may be other types of sources. Additional testing in the vicinity of the airport may help identify sources of the elevated levels of perfluorinated chemicals found in two of the Hyannis wells.

airport

Previous Silent Spring Institute research demonstrated the presence of hormones and pharmaceuticals in Cape Cod ponds due to high density of septic systems upgradient of the ponds. Additional studies of fish populations in Cape ponds, which are fed almost entirely by groundwater, could evaluate whether these chemicals are causing endocrine disruption in these fish populations.

Additional information

Silent Spring Institute

- Cape Cod water studies: http://silentspring.org/our-research/water-research

General information about PPCPs:

- U.S. Environmental Protection Agency: http://www.epa.gov/ppcp
- MA Dept. of Environmental Protection: http://www.mass.gov/dep/toxics/stypes/ppcpedc.htm
- U.S. Geological Survey: http://toxics.usgs.gov/regional/emc/

Associated Press series on pharmaceuticals in drinking water

- Main story: http://hosted.ap.org/specials/interactives/pharmawater_site/
- Results for 28 cities: http://hosted.ap.org/specials/interactives/pharmawater_site/

Proper disposal of medications:

- White House Office of National Drug Control Policy: http://ww.whitehousedrugpolicy.gov/publications/pdf/prescrip_disposal.pdf
- U.S. Food and Drug Administration (FDA): http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm101653.htm

Chemical testing policies:

- Safer Chemicals, Healthy Families: http://www.saferchemicals.org

General information about the Cape Cod Aquifer:

- http://www.capecodgroundwater.org/Cape_Cod_Aquifer.html

Acknowledgements

Funding for this project was made available from:

- Massachusetts Environmental Trust
- U.S. Centers for Disease Control and Prevention

MASSACHUSETTS ENVIRONMENTAL TRUST

We gratefully acknowledge the nine participating water suppliers for their support and partnership in this project. We would like to thank Tom Cambereri, Mark Ells and Deb Krau for their suggestions and input. We would also like to thank Farley Lewis and Ali Criscitiello for assistance with sample collection.

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TABLES AND FIGURES

Table 1. Summary of emerging contaminants detected in 20 Cape Cod public supply wells and 2 distribution systems.

Chemical name	Reporting limit (ng/L)	Number of times detected (out of 22)	Maximum level detected (ng/L)	Health-based guideline values* (ng/L)	Maximum levels found in other drinking water studies (ng/L)	
					Raw (untreated)	Finished (treated)
Pharmaceuticals and personal care products						
Antipyrine	1	1 (5%)	1	n	n	n
Atenolol	0.1	1 (5%)	0.8	n	36[b]	18[b]
Carbamazepine	1	6 (27%)	72	n	4.7[i], 51[b], 190[c]	18[b]
DEET	5	1 (5%)	6	n	74[i], 110[b], 410[c]	93[b]
Dilantin	2	5 (23%)	66	n	29[b]	19[b]
Gemfibrozil	0.5	1 (5%)	1.2	n	<13[i], <15[c], 24[b]	2.1[b]
Meprobamate	0.1	5 (23%)	5.4	n	73[b]	42[b]
Sulfamethizole	1	1 (5%)	1	n	<50[c]	n
Sulfamethoxazole	0.1	13 (59%)	113	n	>23[c], 58[i], 110[b]	3[b]
Trimethoprim	0.1	1 (5%)	0.7	n	<13[i], 11[b], 20[c]	<0.25[b]
Organophosphate flame retardants						
TEP	10	6 (27%)	20	n	1[a]	23[h]
TCPP	10	5 (23%)	40	n	720[b]	510[b]
TDCPP	10	1 (5%)	10	n	<500[c], 170[d], 240[i]	23[h], 5500[d]
TBEP	50	1 (5%)	50	n	300[i], 400[d], 960[c]	560[d], 560[h]
TCEP	20	3 (14%)	20	3400	<500[c], 110[i], 260[d], 530[b]	220[d], 470[b], 52[h]
Perfluorinated chemicals						
PFOA	10	3 (14%)	22	40, 300, 400	2.9[e], 31[g], 35[f]	2.9[e], 30[g], 39[f]
PFOS	1	9 (41%)	110	200, 300	8.6[e], 19[f], 29[g]	9.7[e], 14[f], 57[g]
Alkylphenols (9 samples tested)						
4-nonylphenol	250	1 of 9 (11%)	20 J	n	<5000[i], 130[b], >5000[c]	100[b]

Definitions and abbreviations

- Reporting limit = The lowest level of a chemical that can be quantified using a chemical testing method
- ng/L = nanograms per liter, also parts per trillion. A nanogram is one-trillionth of one gram.
- J = chemical was detected above the detection limit but below the reporting limit. This concentration should be considered an estimate.
- n = no data available
- TEP = triethyl phosphate
  TDCPP = tris(1,3-dichloro-2-propyl) phosphate
  TCEP = tris(2-chloroethyl) phosphate
  PFOS = perfluorooctane sulfonate
  TCPP = tris(chloropropyl) phosphate
  TBEP = tris(2-butoxyethyl) phosphate
  PFOA = perfluorooctanoic acid
- n = no data available
- * = see text for references for health-based guideline values

References for Table 1

[a] **Bacaloni A and others, 2008**. Occurrence of organophosphorus flame retardant and plasticizers in three volcanic lakes of central Italy. *Environmental Science & Technology.* 42:1898-1903.

This study tested water from three lakes and nine groundwater wells in Italy for a range of organophosphate flame retardants. All of the locations tested in this study were remote, with possible impacts from nearby small towns, agricultural activities, and tourism. Only the results for TEP in groundwater are presented for these comparisons.

[b] **Benotti MJ and others, 2009.** Pharmaceuticals and endocrine disrupting compounds in U.S. drinking water. *Environmental Science & Technology.* 43:597-603.

This study included 19 large drinking water treatment plants serving 28 million people, including 18 surface water sources and 1 groundwater source. Raw (untreated), finished (treated) and distribution system samples were tested for 51 organic wastewater compounds.

[c] **Focazio MJ and others, 2008.** A national reconnaissance for pharmaceuticals and other organic wastewater contaminants in the United States--II) Untreated drinking water sources. *Science of the Total Environment.* 402:201-216.

This study tested 74 water supplies that ranged in size from very small to very large and included 49 surface water sources and 25 groundwater sources. Samples were tested for 100 organic wastewater compounds. This study included results for raw water samples only.

[d] **Kingsbury JA and others, 2008.** *Anthropogenic organic compounds in source water of nine community water systems that withdraw from streams, 2002–05.* U.S. Geological Survey Scientific Investigations Report 2008–5208.

This study included multiple samples collected from 9 water supplies drawing upon surface water sources. These supplies served 3,000 to 2,000,000 people. Samples were tested for 134 organic wastewater chemicals. This study included results for raw and treated water samples.

[e] **Loos R and others, 2007**. Polar herbicides, pharmaceutical products, perfluorooctanesulfonate (PFOS), perfluorooctanoate (PFOA), and nonylphenol and its carboxylates and ethoxylates in surface and tap waters around Lake Maggiore in Northern Italy. *Analytical and Bioanalytical Chemistry.* 387:1469-1478

This study tested raw water samples from eight locations in a lake in Italy that provides drinking water, as well as samples from the lake's tributary streams and finished tap water from nearby cities. The lake is downstream of domestic and industrial activities, although no known production facilities are mentioned. These samples were tested for 30 organic wastewater compounds. Results are presented for lake samples only.

[f] **NJ DEP, Division of Water Supply, 2007.** *Determination of Perfluorooctanic Acid (PFOA) in Aqueous Samples: Final Report.* Trenton, NJ.

This study measured PFOS and PFOA in raw and finished drinking water samples from 23 systems, at least one in nearly every New Jersey county. Of the 22 drinking water samples reported here, 10 were from locations close to facilities that manufactured or handled PFOS or PFOA, one was intended as an unimpacted control, and the remainder were from areas with previous detections of high levels of organics in drinking water.

[g] **Quiñones O and SA Snyder, 2009**. Occurrence of perfluoroalkyl carboxylates and sulfonates in drinking water utilities and related waters from the United States. *Environmental Science & Technology.* 43:9089-9095.

This study examined eight perfluorinated chemicals at seven drinking water treatment plants with varying levels of wastewater impact. While only results for raw water samples were used for comparison to Cape water supplies, the study also included treated water samples. For each treatment plant, multiple samples were collected over the course of a year, which were averaged in these comparisons.

[h] **Williams DT and others, 1981**. A national survey of tri(haloalkyl)-, trialkyl-, and triarylphosphates in Canadian drinking water. Bulletin of Environmental Contamination and Toxicology. 27:450-457.

This study tested finished drinking water in 29 cities and towns throughout Canada in summer and winter.

[i] **Zimmerman MJ, 2005.** *Occurrence of Organic Wastewater Contaminants, Pharmaceuticals, and Personal Care Products in Selected Water Supplies, Cape Cod, Massachusetts, June 2004.* USGS Open-file Report 2005-1206.

This study tested 8 wells on Cape Cod: 3 public, one semi-public and 4 private wells. Samples were tested for 85 organic wastewater compounds. Results are provided for raw water samples only. This study also included measurements of these chemicals in monitoring wells impacted by a wastewater treatment plant, in a septic system leachfield and in a recirculating sand filter system.

Table 2. The average number of chemicals detected in low, medium and high nitrate samples. The range of values is provided in parentheses. Groundwater with nitrate less than 0.5 mg/L is considered near background quality, and groundwater with nitrate between 0.5 and 2.5 mg/L is considered moderately impacted.[21]

Nitrate	number of samples	average no. of compounds (range)
low (< 0.5 mg/L)	7	0.6 (0 to 3)
medium (0.5 to 2.5 mg/L)	11	3.1 (1 to 8)
high (> 2.5 mg/L)	4	6.5 (1 to 12)

Table 3. The average number of chemicals detected in samples with relatively low and high boron levels. The range of values is provided in parentheses.

Boron	number of samples	average no. of compounds (range)
low (≤ 10 µg/L)	8	0.4 (0 to 1)
high (> 10 µg/L)	14	4.4 (1 to 12)

Table 4. The average number of chemicals detected in wells located in lower and higher residential density areas. The results are categorized according to the percent of land use in a well's recharge area[a] that is used for residential land use. The range of values is provided in parentheses.

% residential land use in well recharge area	number of samples	average no. of compounds (range)
low (around 10% or less)	8	1.9 (0 to 5)
high (around 20% or more)	12	3.4 (0 to 12)

[a] A well's recharge area refers to the entire land area that potentially contributes water to that well.

Table 5a. Uses and typical daily doses for the pharmaceuticals detected in Cape Cod public drinking water.

Notes:

Pharmaceuticals are biologically-active chemicals intended for use in targeted populations. Publicly-available toxicity data are currently limited and insufficient as a basis for setting health-based guidelines for the general population.

Pharmaceutical	Major uses	Typical daily dose[a]		Maximum level detected (ng/L)[c]
		milligrams[b]	nanograms	
Antipyrine (phenazone)	Analgesic for relieving pain of ear infections	not applicable		1
Atenolol	Beta blocker	50	50,000,000	0.8
Carbamazepine	Anti-convulsant (treatment for epilepsy), anti-depressant	100	100,000,000	72
Dilantin (phenytoin)	Anti-convulsant	50	50,000,000	66
Gemfibrozil	Lipid regulator (lowers cholesterol)	1,200	1,200,000,000	1.2
Meprobamate	Anti-anxiety	200	200,000,000	5.4
Sulfamethizole	Antibiotic	500	500,000,000	1
Sulfamethoxazole	Antibiotic	400	400,000,000	113
Trimethoprim	Antibiotic	80	80,000,000	0.7

[a] Adult doses unless doses for children are available.

[b] A milligram is 1,000 micrograms, or 1,000,000 nanograms

[c] Drinking water concentrations from this study are reported in nanograms per liter (ng/L). A common assumption for drinking water consumption is 1-2 liters per day.

Source: www.drugs.com

Table 5b. Major uses and health effects[a] (based on laboratory animal studies) of consumer-product chemicals detected in Cape Cod public drinking water. Note that exposure to these chemicals in consumer products is likely much greater than exposure via the detected concentrations in drinking water.

See Table 1 for full chemical names.

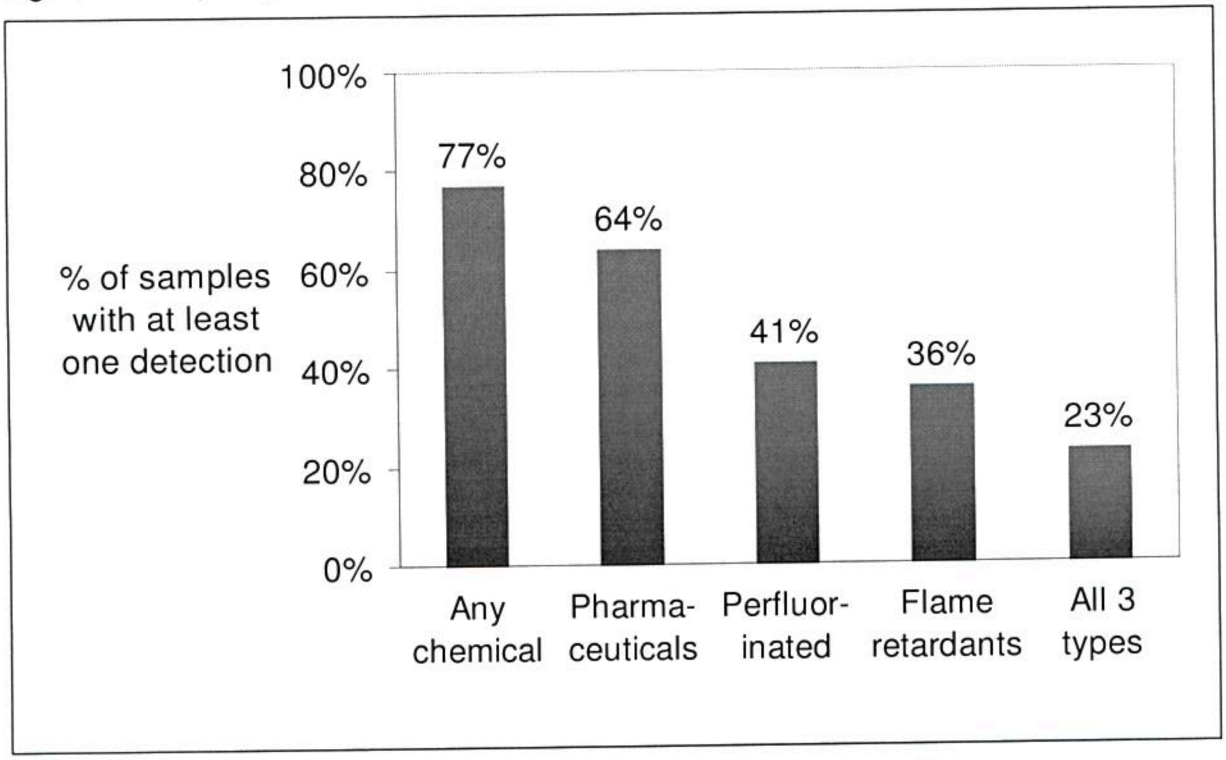
Chemical	Health concerns
Perfluorinated chemicals: used in stain resistant and nonstick surfaces in many household products, metal plating industries, fire-fighting foams	
PFOA	Drinking water health advisories of 40-400 ng/L developed by various regulatory agencies based on effects on liver, blood, and immune systems in animal studies. Effects on mammary gland development have been observed, and there is some evidence of carcinogenicity. Effects on cholesterol metabolism and growth and development have also been observed.
PFOS	Drinking water health advisories of 200-300 ng/L developed by various regulatory agencies based on effects on thyroid and liver in animal studies.
Organophosphate flame retardants: used in furniture foam, textiles, and electronics, some organophosphates have non-flame retardant uses as well, for example as plasticizers	
TEP	Possible neurotoxicity; limited data; Proposed DWAL[b] of 700,000 ng/L for leaching from drinking water supply pipes.
TCPP	Structural similarity to probable carcinogens, such as TDCPP
TDCPP	Carcinogenic, neurotoxic, general toxicity; Consumer Product Safety Commission ADI[c] of 5000 ng/kg-day
TBEP	Possible neurotoxicity; liver toxicity
TCEP	Carcinogenic, neurotoxic; EPA Region 9 drinking water screening level 3,400 ng/L.
Alkylphenols: breakdown products of surfactants used in detergents, some alkylphenols (including 4-nonylphenol) are also used as plasticizers	
4-nonylphenol	Weak estrogen mimic; kidney toxicity
Other chemicals	
DEET (insect repellent)	Approved by EPA for application directly to skin; limited evidence of toxicity.

PFOA

PFOS

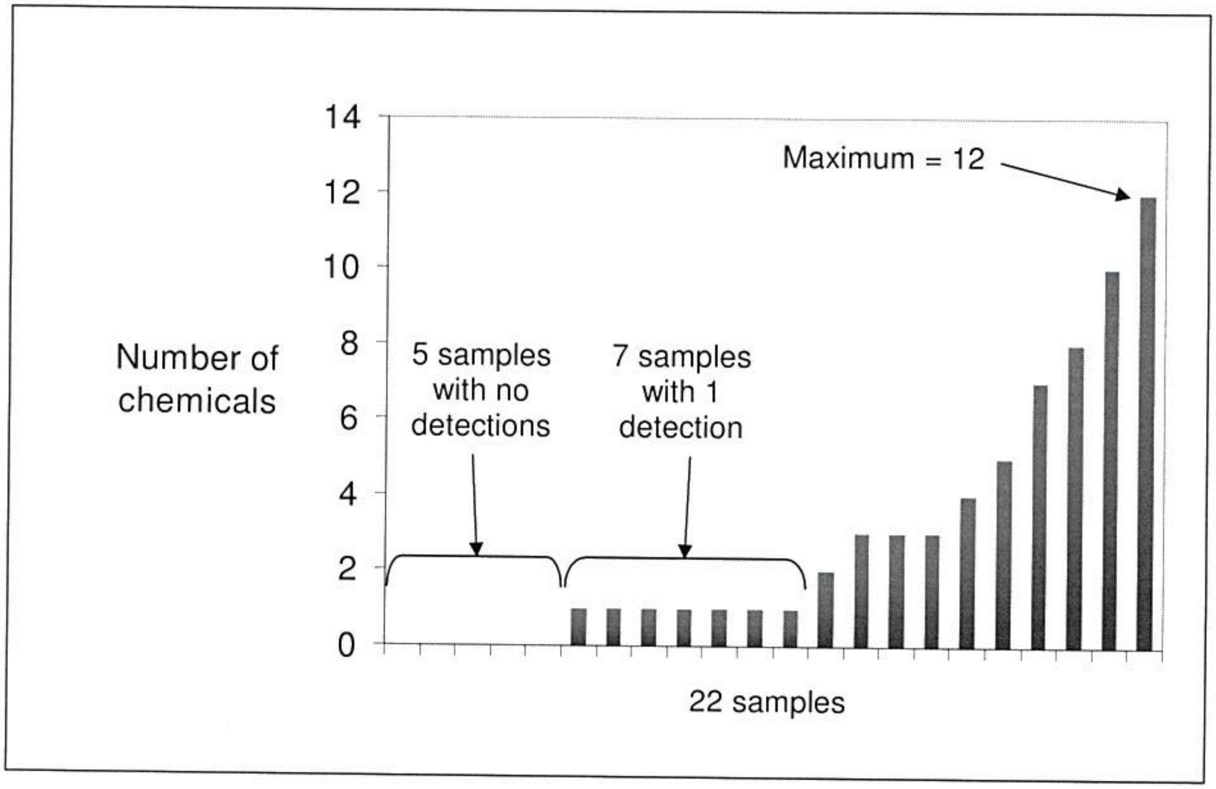
[a] Additional information on the toxicological effects of these chemicals is available from Silent Spring Institute.
[b] DWAL = Drinking water action level for use in water distribution pipes
[c] ADI = Acceptable daily intake, expressed in units of chemical amount per unit body weight per time

Figure 1. Frequency of detection of three categories of emerging contaminants.



Number of drinking water samples (raw and distribution system) that contain at least one emerging contaminant; at least one of chemical classified as a pharmaceutical, organophosphate flame retardant or perfluorinated chemical; and all 3 types of chemicals.

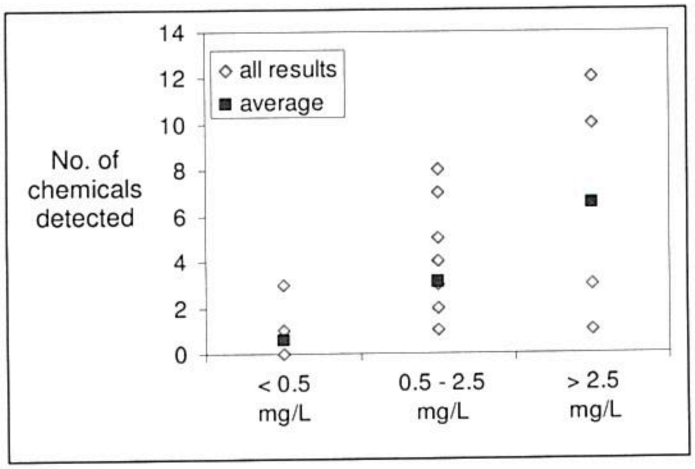
Figure 2. Number of emerging contaminants detected in drinking water samples.



Number of emerging chemicals detected in each of the 20 public supply well samples and 2 distribution system samples.

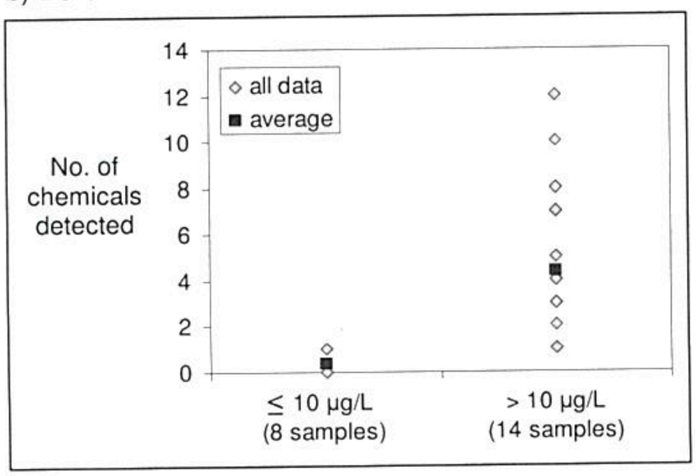
Figure 3. Number of emerging contaminants detected according to levels of nitrate, boron and extent of residential development in well recharge areas.

a) Nitrate



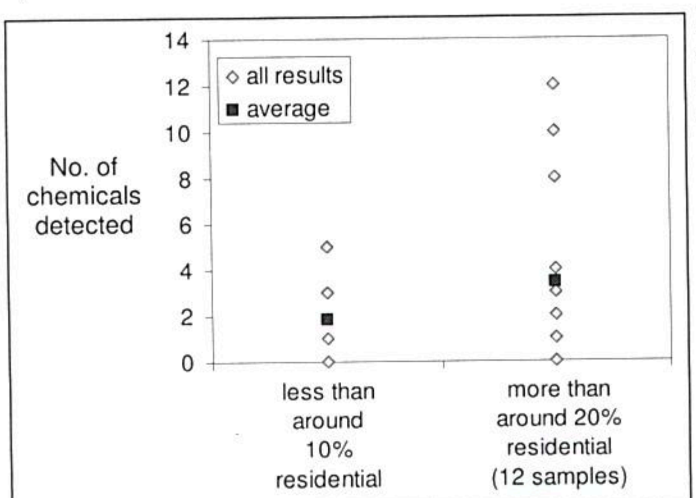
Number of emerging contaminants detected according to levels of nitrate. Groundwater with nitrate less than 0.5 mg/L is considered near background quality, and groundwater with nitrate between 0.5 and 2.5 mg/L is considered moderately impacted.[21]

b) Boron



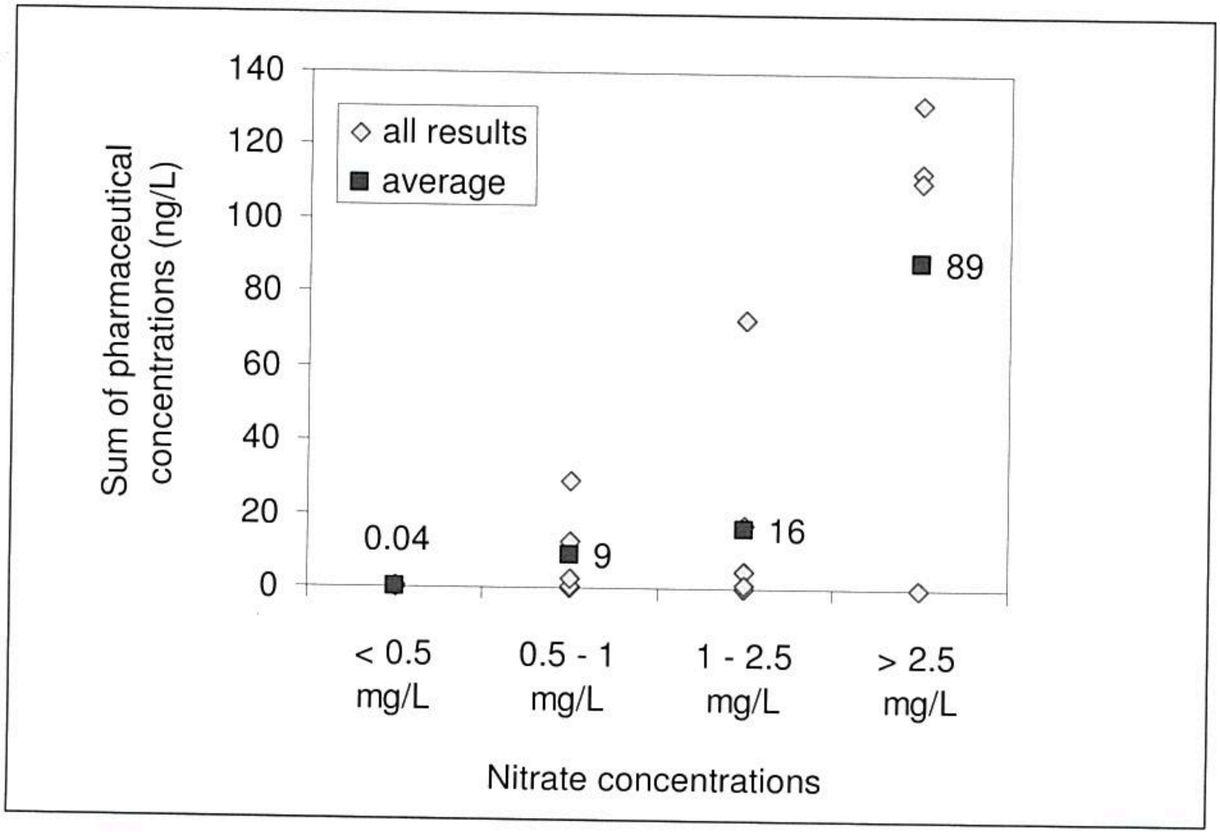
Number of emerging contaminants detected according to boron levels. Boron is present in some laundry detergents, and may be a more specific marker of wastewater impact than nitrate, which can come from fertilizers. However, wells impacted by saltwater intrusion will also have elevated boron levels.

c) Residential land use



Number of emerging contaminants according to the fraction of land use in well recharge areas (Zone IIs) that is attributed to residential development.

Figure 4. Sum of pharmaceutical concentrations in samples according to nitrate concentrations.



APPENDICES

APPENDIX 1

Concentrations of emerging contaminants, nitrate and boron detected in individual Cape Cod drinking water wells

Notes:

We used nitrate and boron as indicators of impact from septic systems. No samples exceeded drinking water standards or guidelines for these two chemicals. Nitrate and boron are naturally occurring, so low levels of these two chemicals are expected even in areas without septic systems or other human impacts. Groundwater with nitrate less than 0.5 mg/L is considered near background quality, and groundwater with nitrate between 0.5 and 2.5 mg/L is considered moderately impacted.[21]

Sample	Chemical name	Concentration detected	
Barnstable Fire District			
Old Barnstable Rd Well 2 (4020000-02G)	Emerging contaminants		
	Sulfamethoxazole	0.2 ng/L	
	Perfluorooctanesulfonic acid (PFOS)	2.5 ng/L	—PFOS
	Tris(2-butoxyethyl) phosphate (TBEP)	50 ng/L	
	Inorganic indicators of septic systems		
	Nitrate	0.7 mg/L	
	Boron	0.016 mg/L	
GP Well 4 (4020000-04G)	Emerging contaminants		
	Perfluorooctanesulfonic acid (PFOS)	13 ng/L	—PFOS
	Inorganic indicators of septic systems		
	Nitrate	1.1 mg/L	
	Boron	0.010 mg/L	
Brewster Water Department			
Freeman's Way Well 1 (4041000-01G)	Emerging contaminants		
	None detected		
	Inorganic indicators of septic systems		
	Nitrate	0.2 mg/L	
	Boron	0.0093 mg/L	
Freeman's Way Well 3 (4041000-03G)	Emerging contaminants		
	None detected		
	Inorganic indicators of septic systems		
	Nitrate	0.1 mg/L	
	Boron	0.0058 mg/L	

Buzzards Bay Water District

Dry Cedar Swamp Road Well 1 (4036001-01G)	Emerging contaminants		
	None detected		
	Inorganic indicators of septic systems		
	Nitrate	0.1	mg/L
	Boron	0.0068	mg/L
Kettle Lane Well 2 (4036001-02G)	Emerging contaminants		
	Sulfamethoxazole	0.3	ng/L
	Inorganic indicators of septic systems		
	Nitrate	0.8	mg/L
	Boron	0.010	mg/L

Centerville-Osterville-Marstons Mills Water Department

Arena Wells 3 & 4 (4020002-02G)	Emerging contaminants		
	Sulfamethoxazole	113	ng/L
	Triethyl phosphate (TEP)	10	ng/L
	Tris(chloropropyl) phosphate (TCPP)	20	ng/L
	Inorganic indicators of septic systems		
	Nitrate	3.2	mg/L
	Boron	0.014	mg/L
Lumbert Mill Well 9 (4020002-05G)	Emerging contaminants		
	Atenolol	0.8	ng/L
	Carbamazepine	5.5	ng/L
	Dilantin (phenytoin)	66	ng/L
	Meprobamate	0.8	ng/L
	Sulfamethoxazole	37.1	ng/L
	Perfluorooctanesulfonic acid (PFOS)	1.7	ng/L
	Triethyl phosphate (TEP)	15	ng/L
	Tris(chloropropyl) phosphate (TCPP)	~7.5	ng/L
	Tris(1,3-dichloro-2-propyl) phosphate (TDCPP)	10	ng/L
	Tris(2-chloroethyl) phosphate (TCEP)	20	ng/L
	Inorganic indicators of septic systems		
	Nitrate	4.6	mg/L
	Boron	0.028	mg/L
Harrison GP 19 (4020002-16G)	Emerging contaminants		
	None detected		
	Inorganic indicators of septic systems		
	Nitrate	None detected	
	Boron	None detected	

Chatham Water Department

Indian Hill Well 1 (4055000-04G) note: this well is currently off-line	Emerging contaminants		
	Perfluorooctanesulfonic acid (PFOS)	2.2	ng/L
	Inorganic indicators of septic systems		
	Nitrate	2.6	mg/L
	Boron	0.032	mg/L
Town Forest Well 9 (4055000-09G)	Emerging contaminants		
	None detected		
	Inorganic indicators of septic systems		
	Nitrate	None detected	
	Boron	0.006*	mg/L
Distribution System Sample	Emerging contaminants		
	Sulfamethoxazole	0.3	ng/L
	Inorganic indicators of septic systems		
	Nitrate	0.4	mg/L
	Boron	0.012	mg/L

PFOS

Cotuit Water Department

Electric Station Well 1 (4020003-02G)	Emerging contaminants		
	Carbamazepine	20	ng/L
	Dilantin (phenytoin)	47	ng/L
	Meprobamate	2.5	ng/L
	Sulfamethoxazole	3.2	ng/L
	Inorganic indicators of septic systems		
	Nitrate	2	mg/L
	Boron	0.015	mg/L
Station 5 (4020003-06G)	Emerging contaminants		
	Sulfamethoxazole	0.9	ng/L
	Inorganic indicators of septic systems		
	Nitrate	1.6	mg/L
	Boron	0.065	mg/L

*Corrected value

Dennis Water Department

Bakers Pond Well 14 (4075000-15G)	Emerging contaminants		
	Sulfamethoxazole	1	ng/L
	Inorganic indicators of septic systems		
	Nitrate	1.8	mg/L
	Boron	0.019*	mg/L
GP 21 (4075000-21G)	Emerging contaminants		
	Sulfamethoxazole	17.1	ng/L
	PFOS	1.4	ng/L
	Inorganic indicators of septic systems		
	Nitrate	2.5	mg/L
	Boron	0.020	mg/L

PFOS

Falmouth Water Department

Fresh Pond Well (4096000-02G)	Emerging contaminants		
	Carbamazepine	1	ng/L
	Sulfamethoxazole	2.9	ng/L
	Trimethoprim	0.7	ng/L
	Tris(2-chloroethyl) phosphate (TCEP)	20	ng/L
	4-Nonylphenol	20[J]	ng/L
	Inorganic indicators of septic systems		
	Nitrate	1.2	mg/L
	Boron	0.012	mg/L
Crooked Pond Well (4096000-05G)	Emerging contaminants		
	Sulfamethoxazole	2.8	ng/L
	Inorganic indicators of septic systems		
	Nitrate	0.9	mg/L
	Boron	0.015	mg/L

Tris

* Corrected value

J Estimated value; concentration detected between the detection limit and reporting limit. See Appendix 3 for additional QA/QC information about this sample.

Hyannis Water System

Maher Well 2 (4020004-02G)	Emerging contaminants		
	Carbamazepine	9	ng/L
	Dilantin (phenytoin)	10	ng/L
	Meprobamate	3.8	ng/L
	Sulfamethoxazole	6.1	ng/L
	Perfluorooctanoic acid (PFOA)	22	ng/L
	Perfluorooctanesulfonic acid (PFOS)	97	ng/L
	Triethyl phosphate (TEP)	10	ng/L
	Tris(chloropropyl) phosphate (TCPP)	30	ng/L
	Inorganic indicators of septic systems		
	Nitrate	0.9	mg/L
	Boron	0.016	mg/L
Hyannisport Well (4020004-03G)	Emerging contaminants		
	Antipyrine	1	ng/L
	Carbamazepine	72	ng/L
	DEET	6	ng/L
	Dilantin (phenytoin)	4	ng/L
	Gemfibrozil	1.2	ng/L
	Meprobamate	5.4	ng/L
	Sulfamethizole	1	ng/L
	Sulfamethoxazole	41	ng/L
	Perfluorooctanesulfonic acid (PFOS)	15	ng/L
	Triethyl phosphate (TEP)	10	ng/L
	Tris(chloropropyl) phosphate (TCPP)	~13	ng/L
	Tris(2-chloroethyl) phosphate (TCEP)	20	ng/L
	Inorganic indicators of septic systems		
	Nitrate	5.3	mg/L
	Boron	0.037	mg/L
Airport Well 1 (4020004-10G)	Emerging contaminants		
	Perfluorooctanoic acid (PFOA)	14	ng/L
	Perfluorooctanesulfonic acid (PFOS)	16	ng/L
	Triethyl phosphate (TEP)	10	ng/L
	Inorganic indicators of septic systems		
	Nitrate	0.3	mg/L
	Boron	0.011	mg/L

Hyannis Water System (continued)

Distribution System Sample	Emerging contaminants		
	Carbamazepine	3	ng/L
	Dilantin (phenytoin)	7	ng/L
	Meprobamate	2.7	ng/L
	Perfluorooctanoic acid (PFOA)	22	ng/L
	Perfluorooctanesulfonic acid (PFOS)	110	ng/L
	Triethyl phosphate (TEP)	20	ng/L
	Tris(chloropropyl) phosphate (TCPP)	40	ng/L
	Inorganic indicators of septic systems		
	Nitrate	0.9	mg/L
	Boron	0.017	mg/L

APPENDIX 2

Complete list of chemicals measured (detected and not detected) in Cape Cod public supply wells

RL = laboratory reporting limit (lowest level quantified by the laboratory)
** = chemicals detected in at least one sample

Chemical	RL (ng/L)
Pharmaceuticals – antibiotics	
azithromycin	5
bacitracin	1000
carbadox	5
chloramphenicol	5
chlorotetracycline	50
ciprofloxacin	50
doxycycline	50
enrofloxacin	50
erythromycin	1
lasalocid	1
lincomycin	0.1
monensin	1
narasin	1
norfloxacin	50
oleandomycin	1
oxytetracycline	500
penicillin	2
roxithromycin	1
salinomycin	0.1
sulfachloropyridazine	5
sulfadiazine	1
sulfadimethoxine	0.1
sulfamerazine	1
sulfamethazine	1
sulfamethizole**	**1**
sulfamethoxazole**	**0.1**
sulfathiazole	1
trimethoprim**	**0.1**
tylosin	1
virginiamycin	1

Chemical	RL (ng/L)
Pharmaceuticals – prescription	
antipyrine**	**1**
atenolol**	**0.1**
bezafibrate	0.5
carbamazepine**	**1**
clofibric acid	0.5
diclofenac	0.5
dilantin (phenytoin)**	**2**
diltiazem	0.1
fluoxetine (Proxac)	1
gemfibrozil**	**0.5**
levothyroxine	2
meprobamate**	**0.1**
naproxen	2
prednisone	2
simvastatin	5
theophylline	5
Pharmaceuticals – non-prescription	
acetaminophen	5
caffeine	10
cotinine	1
ibuprofen	50
nicotine	5
paraxanthine	5
theobromine	50

(continued)

Chemical	RL (ng/L)
Hormones	
17-alpha-estradiol	0.5
17-beta-estradiol	0.5
17-alpha-ethynylestradiol	0.5
diethylstilbestrol (DES)	0.5
estriol	0.5
estrone	0.5
progesterone	0.1
testosterone	0.1
Perfluorinated compounds	
perfluorooctanoic acid (PFOA)**	**10**
perfluorooctane sulfonate (PFOS)**	**1**
Personal care product ingredients	
DEET**	**5**
galaxolide (HHCB)	10
tonalid (AHTN)	10
Triclosan	50
Alkylphenols *(analyzed in a subset of samples)*	
4-nonylphenol**	**250**
4-nonylphenol mono-ethoxylate	1500
4-nonylphenol diethoxylate	1500
Octylphenol	250

Chemical	RL (ng/L)
Phosphate flame retardants	
diphenylcresyl phosphate	10
2-ethylhexyldiphenyl phosphate	10
tributyl phosphate	10
tri-m-cresyl phosphate	10
tri-o-cresyl phosphate	10
tri-p-cresyl phosphate	10
triethyl phosphate**	**10**
trimethyl phosphate	10
tripentyl phosphate	10
triphenyl phosphate	10
tris(2-butoxyethyl) phosphate**	**50**
tris(2-chloroethyl) phosphate**	**10**
tris(chloropropyl) phosphate**	**10**
tris(2,3-dibromopropyl) phosphate	100
tris(1,3-dichloro-2-propyl) phosphate**	**10**
tris(2-ethylhexyl) phosphate	10
Herbicides	
2,4-D	5
dicamba	50
dichlorprop	5
MCPA	5
triclopyr	5

APPENDIX 3

Summary of quality assurance/quality control (QA/QC) samples

Blanks: Two field blanks were collected over the course of our sampling. Field blanks were collected by pouring analytical-grade water that we received from the laboratory into sampling bottles at two of the field sites. When analyzing our samples, the laboratory did not know which samples were field blanks. No chemicals were detected in any of our field blanks.

For the alkylphenol analysis, there was one laboratory blank that contained trace levels of 4-nonylphenol. A laboratory blank is a blank that is the laboratory analyzes along side the actual samples. 4-nonylphenol was only detected in one sample, and the estimated concentrations in the sample and the laboratory blank were both below the reporting limit, but above the detection limit. For this sample, the estimated concentration in the sample was approximately 3 times higher than the concentration present in the laboratory blank.

Duplicates: Two samples were collected in duplicate over the course of our sampling. Duplicate samples were collected at the same location into separate collection bottles. When analyzing our samples, the laboratory did not know which samples were duplicates.

In general, the results of the duplicate analyses showed very good reproducibility (see Table A3).

- For pharmaceuticals and personal care products, the average percent difference was 3% (range: 0% to 18%). Four chemicals were detected in both of the duplicate samples.
- For PFOS, which was detected in both duplicate samples, the results were identical (percent difference was 0%).
- For 4 organophosphate flame retardants detected in at least one of the duplicates, there was more of a range in the reproducibility. We attribute these differences in part to the fact that the analytical laboratory only reported one significant figure for these results, so some differences may appear artificially large. For 4 detections, the duplicate results were identical (0% different), and for 3 detections, the difference was >50%.

Table A3. Percent difference between duplicate analyses. Two well water samples were collected in duplicate. The percent difference is determined as the difference between the two values divided by the average of the two values. For organophosphate flame retardants, the percent difference appears higher in part because concentrations were only reported to one significant digit. See Table 1 for full chemical names.

-- not detected in either duplicate
** percent difference could not be calculated because one duplicate was above the reporting limit and the other was below the reporting limit

	Pharmaceuticals								
	antipyrine	atenolol	carbamaze-pine	DEET	dilantin	gemfibrozil	meproba-mate	sulfamethi-zole	sulfameth-oxazole
Sample 1	--	0%	18%	--	3%	--	0%	--	3%
Sample 2	0%	--	3%	0%	0%	0%	11%	0%	1%

	Perfluorinated chemicals	Organophosphate flame retardants			
	PFOS	TEP	TCPP	TDCPP	TCEP
Sample 1	0%	67%	**	0%	0%
Sample 2	0%	0%	**	--	0%